THE UNIVERSITY OF CALGARY

Department of CIVIL ENGINEERING

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February 5, 1988

CONTRACT REPORT NUMBER 69014-01-ST
CONTRACTOR: University of Calgary
REQUISITION NUMBER 23440-6-9014

Mr. G.C. Carette
CANMET
405 Rochester Street
Ottawa, Ontario
K1A 0G1

Dear Mr. Carette:

Re: DSS File No. 41 ST. 23440-6-9014 "Creep Studies on Portland Cement/Slag Concrete"

This constitutes the final report on the subject contract with revised completion deadline of March 31, 1988.

All raw data and summary sheets showing the computation of creep at various ages up to 1 year are appended.

The set of creep rigs, which we have referred to as the low-load rigs, is now free and available for further tests if and when required.

Yours sincerely,

C.D. Johnston
Professor of Civil Engineering

CDJ/kt
Encls.
cc: Pat Aldridge, Trust Acct.
Pat Foster, Technology Transfer

CREEP TEST SUMMARY (ASTM C 512)

Mix Designation 551 Date of Mixing OCT. 7/86

Specimen Numbers 551-1-4

Curing Regime Days Moist 41, Days at 50% R.H. _____

Date of Loading NOV. 17/86 Age 41 days, Compressive Strength _____ MPa

Applied Stress 8.77 MPa Stress/Strength Ratio _____

Instantaneous Elastic Strain 294 με Instantaneous Modulus _____ GPa

Specific Creep _____ Creep Rate _____

Notes:

Strain Data Summary-με

Date	Time under load - days	Loaded Specimens 551-1	551-2	Unloaded Specimens 551-3	551-4	Creep Strain			
NOV 17/86	0	290	297	–	–	–			
17/86	3.8 HRS	320	330	3	0	30			
18/86	1	397	413	17	17	94			
19/86	2	440	453	27	27	126			
20/86	3	473	490	37	27	156			
21/86	4	507	517	43	47	173			
24/86	7	567	583	70	67	213			
EC. 01/86	14	667	687	107	100	280			
08/86	21	743	763	140	127	326			
17/86	30	817	850	167	157	378			
AN 15/87	59	1007	1050	233	223	507			
EB. 13/87	88	1133	1190	280	273	591			
AR. 16/87	119	1233	1297	317	300	663			
PR. 16/87	150	1307	1377	350	337	705			
AY 14/87	178	1340	1420	353	343	738			
UN. 19/87	214	1403	1483	387	373	769			
ULY 17/87	242	1427	1507	397	387	781			
—	270	—	—	—	—	—	—		
EPT. 17/87	304	1487	1563	407	400	828			
CT. 14/87	331	1510	1593	420	407	844			
OV. 20/87	369	1547	1630	440	423	863			

CREEP TEST SUMMARY (ASTM C 512)

Mix Designation 552 Date of Mixing OCT. 09/86

Specimen Numbers 552-1-4

Curing Regime Days Moist 41, Days at 50% R.H. _____

Date of Loading NOV 19/86 Age 41 days, Compressive Strength _____ MPa

Applied Stress 8.77 MPa Stress/Strength Ratio _____

Instantaneous Elastic Strain 278 με Instantaneous Modulus _____ GPa

Specific Creep _____ Creep Rate _____

Notes:

Strain Data Summary-με

Date	Time under load - days	Loaded Specimens 552-1	552-2	Unloaded Specimens 552-3	552-4	Creep Strain
NOV. 19/86	0	273	283	—	—	—
19/86	5.0 HRS	307	320	0	3	34
20/86	1	353	367	17	13	67
21/86	2	380	400	20	17	94
24/86	5	437	460	40	37	132
25/86	6	447	470	50	47	132
26/86	7	467	493	50	50	152
DEC. 3/86	14	540	570	70	73	206
10/86	21	590	627	90	93	239
17/86	28	647	683	120	117	269
JAN 15/87	57	807	857	177	173	379
FEB. 18/87	91	930	993	223	223	461
MAR. 17/87	118	1010	1070	257	257	505
APR. 16/87	148	1087	1153	287	290	554
MAY 15/87	177	1137	1203	297	300	594
JUN. 19/87	212	1217	1287	330	337	641
JULY 17/87	240	1253	1323	350	353	659
	27					
SEPT. 17/87	302	1343	1410	377	387	717
OCT. 14/87	329	1380	1447	393	400	739
NOV. 20/87	366	1440	1510	417	417	780

CREEP TEST SUMMARY (ASTM C 512)

Mix Designation 553 Date of Mixing OCT. 15/86

Specimen Numbers 553-1-4

Curing Regime Days Moist _____, Days at 50% R.H. _____

Date of Loading NOV. 25/86 Age 41 days, Compressive Strength _____ MPa

Applied Stress 8.77 MPa Stress/Strength Ratio _____

Instantaneous Elastic Strain 283 με Instantaneous Modulus _____ GPa

Specific Creep _____ Creep Rate _____

Notes:

Strain Data Summary-με

Date	Time under load - days	Loaded Specimens 553-1	553-2	Unloaded Specimens 553-3	553-4	Creep Strain			
NOV. 25/86	0	273	293	—	—	—			
25/86	4.2 HRS	313	340	0	-7	47			
26/86	1	357	393	0	0	92			
27/86	2	393	420	0	0	124			
28/86	3	413	450	0	3	147			
DEC. 1/86	6	467	507	20	27	181			
2/86	7	480	527	27	37	189			
9/86	14	563	617	60	63	246			
17/86	22	650	707	80	90	311			
23/86	28	700	763	100	107	345			
JAN. 26/87	62	870	943	167	177	452			
FEB. 27/87	94	987	1070	223	227	571			
MAR. 27/87	122	1083	1170	263	263	581			
APR. 24/87	150	1147	1240	287	287	674			
MAY 25/87	181	1187	1293	297	300	659			
JUN. 26/87	213	1270	1373	340	347	695			
JULY 30/87	247	1313	1410	357	357	722			
SEPT. 25/87	304	1390	1507	387	387	779			
OCT. 23/87	332	1427	1540	403	397	801			
NOV. 27/87	367	1497	1610	423	417	851			

CREEP TEST SUMMARY (ASTM C 512)

Mix Designation 554 Date of Mixing OCT. 15/86

Specimen Numbers 554-1-4

Curing Regime Days Moist 41, Days at 50% R.H. _____

Date of Loading NOV 25/86 Age 41 days, Compressive Strength _____ MPa

Applied Stress 8.77 MPa Stress/Strength Ratio _____

Instantaneous Elastic Strain 290 με Instantaneous Modulus _____ GPa

Specific Creep _____ Creep Rate _____

Notes:

Strain Data Summary-με

Date	Time under load - days	Loaded Specimens 554-1	554-2	Unloaded Specimens 554-3	554-4	Creep Strain
NOV. 25/86	0	287	293	—	—	—
26/86	4.25 HRS	323	327	3	3	32
27/86	1	383	393	17	20	80
26/86	2	420	430	33	33	102
27/86	3	447	460	43	40	122
DEC. 1/86	6	520	533	73	67	167
2/86	7	543	557	90	80	175
9/86	14	660	673	137	130	243
17/86	22	743	763	167	167	296
23/86	28	800	817	193	193	326
JAN 26/87	62	1070	1053	280	290	462
FEB. 27/87	94	1153	1187	337	350	537
MAR. 27/87	122	1260	1300	373	393	607
APR. 24/87	150	1330	1373	393	417	657
MAY 25/87	181	1373	1430	403	477	697
JUN. 26/87	213	1463	1510	450	480	732
JULY 30/87	247	1503	1550	457	483	767
SEPT. 25/87	304	1590	1640	480	517	827
OCT. 23/87	332	1623	1667	493	523	847
NOV. 27/87	367	1683	1730	510	540	892

CREEP TEST SUMMARY (ASTM C 512)

Mix Designation 555 Date of Mixing DEC. 15/86

Specimen Numbers 555-5-8

Curing Regime Days Moist 41, Days at 50% R.H. _____

Date of Loading JAN. 26/87 Age 41 days, Compressive Strength _____ MPa

Applied Stress 8.77 MPa Stress/Strength Ratio _____

Instantaneous Elastic Strain 294 με Instantaneous Modulus _____ GPa

Specific Creep _____ Creep Rate _____

Notes:

Strain Data Summary-με

Date	Time under load - days	Loaded Specimens 555-5	Loaded Specimens 555-6	Unloaded Specimens 555-7	Unloaded Specimens 555-8	Creep Strain			
JAN. 26/87	0	297	290	—	—	—			
26/87	4.45 HRS	353	347	3	3	53			
27/87	1	420	417	23	20	103			
28/87	2	453	447	33	33	123			
29/87	3	480	470	40	37	143			
30/87	4	503	497	43	43	163			
FEB. 2/87	7	557	547	63	60	197			
10/87	15	660	647	110	110	250			
16/87	21	—	—	—	—	—			
27/87	32	800	780	167	173	326			
MAR. 27/87	60	957	940	230	240	420			
APR. 27/87	92	1073	1060	270	283	496			
MAY 26/87	120	1123	1117	290	300	531			
JUN. 26/87	151	1217	1203	340	350	571			
JULY 30/87	185	1270	1257	357	370	606			
SEPT. 25/87	242	1347	1340	390	407	651			
OCT. 23/87	270	1383	1373	400	417	676			
NOV. 23/87	301	1437	1427	423	433	710			
DEC. 24/87	332	1460	1447	430	447	721			
JAN 29/88	368	1493	1477	440	457	743			

CREEP TEST SUMMARY (ASTM C 512)

Mix Designation 556 Date of Mixing DEC. 15/86

Specimen Numbers 556-5-8

Curing Regime Days Moist 41, Days at 50% R.H. _____

Date of Loading JAN. 26/87 Age 41 days, Compressive Strength _____ MPa

Applied Stress 8.77 MPa Stress/Strength Ratio _____

Instantaneous Elastic Strain 317 με Instantaneous Modulus _____ GPa

Specific Creep _____ Creep Rate _____

Notes:

Strain Data Summary-με

Date	Time under load - days	Loaded Specimens 556-5	556-6	Unloaded Specimens 556-7	556-8	Creep Strain
JAN. 26/87	0	313	320	—	—	—
26/87	5.0 HRS	373	387	10	10	53
27/87	1	463	470	27	27	123
28/87	2	500	510	40	40	148
29/87	3	530	540	47	47	171
30/87	4	557	567	57	53	190
FEB. 2/87	7	620	623	77	73	230
10/87	15	737	747	173	127	300
16/87	21	—	—	—	—	—
27/87	32	877	887	183	190	379
MAR. 27/87	60	1047	1070	250	263	485
APR. 29/87	92	1163	1177	290	303	557
MAY 26/87	120	1207	1230	310	323	585
JUN. 26/87	151	1300	1317	357	370	628
JULY 30/87	185	1350	1357	377	383	657
SEPT. 25/87	242	1427	1443	407	420	705
OCT. 23/87	270	1460	1473	430	430	720
NOV. 23/87	301	1510	1530	440	450	758
DEC. 24/87	332	1533	1547	447	460	770
JAN. 29/88	368	1563	1570	457	470	786

CREEP TEST SUMMARY (ASTM C 512)

Mix Designation SS7- Date of Mixing DEC. 15/86

Specimen Numbers SS7-5-8

Curing Regime Days Moist 41, Days at 50% R.H. _____

Date of Loading JAN 26/87 Age 41 days, Compressive Strength _____ MPa

Applied Stress 8.77 MPa Stress/Strength Ratio _____

Instantaneous Elastic Strain 314 με Instantaneous Modulus _____ GPa

Specific Creep _____ Creep Rate _____

Notes:

Strain Data Summary-με

Date	Time under load - days	Loaded Specimens SS7-5	Loaded Specimens SS7-6	Unloaded Specimens SS7-7	Unloaded Specimens SS7-8	Creep Strain			
JAN. 26/87	0	317	310	—	—				
26/87	5.17 HRS	377	373	7	0	58			
27/87	1	470	453	23	17	128			
28/87	2	510	497	40	23	158			
29/87	3	543	527	47	37	179			
30/87	4	573	557	60	47	198			
FEB. 2/87	7	540	620	83	67	241			
10/87	15	780	750	140	123	370			
16/87	21	—	—	—	—	—			
27/87	32	953	917	213	203	413			
MAR. 27/87	60	1153	1113	293	273	536			
APR. 28/87	92	1297	1250	343	327	625			
MAY 26/87	120	1367	1317	357	343	678			
JUN. 26/87	151	1470	1413	417	403	718			
JULY 30/87	185	1527	1473	427	413	766			
OCT. 14/87	261	1640	1593	467	460	839			
OCT. 23/87	270	1650	1603	476	470	840			
NOV 23/87	301	1710	1660	497	487	879			
DEC. 24/87	332	1733	1687	503	490	900			
JAN. 28/88	368	1767	1720	513	500	923			

CREEP TEST SUMMARY (ASTM C 512)

Mix Designation 558 Date of Mixing DEC. 17/86

Specimen Numbers 558-5-8

Curing Regime Days Moist 41, Days at 50% R.H. _____

Date of Loading JAN. 28/87 Age 41 days, Compressive Strength _____ MPa

Applied Stress 8.77 MPa Stress/Strength Ratio _____

Instantaneous Elastic Strain 300 με Instantaneous Modulus _____ GPa

Specific Creep _____ Creep Rate _____

Notes:

Strain Data Summary-με

Date	Time under load - days	Loaded Specimens 558-5	Loaded Specimens 558-6	Unloaded Specimens 558-7	Unloaded Specimens 558-8	Creep Strain			
JAN. 28/87	0	293	307	—	—	—	—		
28/87	5.5 HRS	360	380	0	7	67			
29/87	1	443	457	73	27	125			
30/87	2	487	503	40	50	150			
FEB. 2/87	5	577	590	73	83	206			
3/87	6	603	620	83	93	224			
4/87	7	627	647	97	107	235			
11/87	14	747	760	150	157	300			
18/87	21	—	—	—	—				
MAR. 3/87	34	917	947	227	230	404			
31/87	62	1070	1110	297	300	492			
APR. 28/87	90	1173	1213	337	333	558			
MAY 28/87	120	1227	1290	360	350	604			
JULY 8/87	161	1317	1360	403	397	639			
JULY 30/87	183	1337	1387	410	400	657			
OCT. 14/87	259	1427	1477	447	433	712			
NOV. 24/87	300	1473	1520	467	453	737			
DEC. 24/87	330	1487	1547	477	460	749			
JAN. 29/88	366	1510	1567	487	463	764			

CREEP TEST SUMMARY (ASTM C 512)

Mix Designation 559 Date of Mixing DEC. 17/86

Specimen Numbers 559-5-8

Curing Regime Days Moist 41, Days at 50% R.H. _____

Date of Loading JAN. 28/87 Age 41 days, Compressive Strength _____ MPa

Applied Stress 8.70* MPa Stress/Strength Ratio _____

Instantaneous Elastic Strain 287 με Instantaneous Modulus _____ GPa

Specific Creep _____ Creep Rate _____

Notes: *MIX 9-11 LOADING RAM DIA. 15.728 IN² COMPARED TO 15.904 IN² FOR MIXES 1-8

Strain Data Summary-με

Date	Time under load - days	Loaded Specimens 559-5	559-6	Unloaded Specimens 559-7	559-8	Creep Strain			
JAN 28/87	0	283	290	—	—	—			
28/87	5.25 HRS	320	330	10	3	32			
29/87	1	377	387	20	13	79			
30/87	2	410	420	33	23	100			
FEB. 2/87	5	473	490	60	50	140			
3/87	6	493	507	70	57	150			
4/87	7	513	533	80	67	163			
11/87	14	607	620	123	110	210			
~~12~~	21	—	—	—	—				
MAR. 3/87	34	750	770	193	177	288			
31/87	62	893	917	253	240	372			
APR. 28/87	90	980	1013	297	280	421			
MAY 28/87	120	1030	1077	310	300	462			
JULY 8/87	161	1137	1167	363	350	509			
JULY 30/87	183	1160	1200	373	357	528			
OCT. 14/87	259	1270	1313	410	397	601			
NOV. 24/87	300	1337	1380	430	420	647			
DEC. 24/87	330	1360	1407	440	430	662			
JAN. 29/88	366	1397	1443	450	443	687			

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CREEP TEST SUMMARY (ASTM C 512)

Mix Designation 5510 **Date of Mixing** DEC. 17/86

Specimen Numbers 5510-5

Curing Regime **Days Moist** 41, **Days at 50% R.H.** _____

Date of Loading JAN. 28/87 **Age** 41 **days, Compressive Strength** _____ MPa

Applied Stress 8.70 MPa **Stress/Strength Ratio** _____

Instantaneous Elastic Strain 280 με **Instantaneous Modulus** _____ GPa

Specific Creep _____ **Creep Rate** _____

Notes:

Strain Data Summary-με

Date	Time under load - days	Loaded Specimens 5510-5	Loaded Specimens 5510-6	Unloaded Specimens 5510-7	Unloaded Specimens 5510-8	Creep Strain
JAN 28/87	0	273	287	—	—	—
28/87	4.63 HRS	313	320	0	0	37
29/87	1	360	370	10	7	77
30/87	2	393	407	20	23	99
FEB. 2/87	5	457	463	47	50	132
3/87	6	470	480	57	57	138
4/87	7	493	500	70	70	147
11/87	14	577	590	110	110	194
~~18/87~~	—	—	—	—	—	—
MAR. 3/87	34	710	730	180	177	262
31/87	62	827	853	243	243	317
APR. 28/87	90	920	947	280	273	377
MAY 28/87	120	973	1000	300	300	407
JULY 8/87	161	1057	1090	357	350	440
JULY 30/87	183	1087	1110	367	360	455
OCT. 14/87	259	1173	1203	403	403	505
NOV. 24/87	300	1237	1263	427	430	547
DEC. 24/87	330	1260	1290	437	440	557
JAN. 29/88	366	1290	1337	450	450	584

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CREEP TEST SUMMARY (ASTM C 512)

Mix Designation SS11 Date of Mixing DEC. 17/86

Specimen Numbers SS11-5-8

Curing Regime Days Moist 41, Days at 50% R.H. 1

Date of Loading JAN 28/87 Age 41 days, Compressive Strength _____ MPa

Applied Stress 8.70 MPa Stress/Strength Ratio _____

Instantaneous Elastic Strain 272 με Instantaneous Modulus _____ GPa

Specific Creep _____ Creep Rate _____

Notes:

Strain Data Summary-με

Date	Time under load - days	Loaded Specimens SS11-5	Loaded Specimens SS11-6	Unloaded Specimens SS11-7	Unloaded Specimens	Creep Strain			
JAN 28/87	0	267	277	—	—	—			
28/87	4.53 HRS	307	307	0	3	34			
29/87	1	357	367	17	20	72			
30/87	2	393	403	23	37	96			
FEB. 2/87	5	460	467	53	67	137			
3/87	6	480	490	67	77	141			
4/87	7	503	510	73	87	155			
11/87	14	593	610	123	137	200			
~~18/87~~	~~21~~	—		—					
MAR 3/87	34	750	770	197	213	283			
31/87	62	893	930	267	290	361			
APR. 28/87	90	980	1027	317	330	408			
MAY 28/87	120	1037	1087	337	353	445			
JULY 8/87	161	1127	1183	390	407	485			
JULY 30/87	183	1157	1210	403	417	502			
OCT. 14/87	259	1260	1317	443	453	569			
NOV. 24/87	300	1327	1377	463	473	612			
DEC. 24/87	330	1353	1413	473	487	631			
JAN. 29/88	366	1387	1447	487	493	655			